What is claimed is:

1. A limit cycle autotuning method of calculating a control parameter by alternately performing operation of outputting a predetermined heat-side manipulated variable set point to a heating actuator and operation of outputting a predetermined cool-side manipulated variable set point to a cooling actuator in a heat/cool control apparatus which performs temperature control by performing feedback control computation with respect to a deviation between a set point and a controlled variable on the basis of the control parameter, and properly switching a heat mode of outputting a manipulated variable to the heating actuator and a cool mode of outputting a manipulated variable to a cooling actuator, comprising:

the first limit cycle generation step of generating a first limit cycle of alternately outputting the heat-side manipulated variable set point and the cool-side manipulated variable set point;

the first control response detection step of detecting a first control response corresponding to the first limit cycle;

the second limit cycle generation step of generating a second limit cycle by changing one of the heat-side manipulated variable set point and the cool-side manipulated variable set point on the basis of

predetermined change instruction information for instructing which one of the heat-side manipulated variable set point and the cool-side manipulated variable set point is to be changed after the first limit cycle and a predetermined manipulated variable change ratio indicating a degree of the change;

the second control response detection step of detecting a second control response corresponding to the second limit cycle; and

the control parameter calculation step of calculating the control parameter for each of the heat mode and the cool mode on the basis of the detected first and second control responses.

2. A limit cycle autotuning method of calculating a control parameter by alternately performing operation of outputting a predetermined heat-side manipulated variable set point to a heating actuator and operation of outputting a predetermined cool-side manipulated variable set point to a cooling actuator in a heat/cool control apparatus which performs temperature control by performing feedback control computation with respect to a deviation between a set point and a controlled variable on the basis of the control parameter, and properly switching a heat mode of outputting a manipulated variable to the heating actuator and a cool mode of outputting a manipulated variable to a cooling

actuator, comprising:

the first limit cycle generation step of generating a first limit cycle of alternately outputting the heat-side manipulated variable set point and the cool-side manipulated variable set point;

the first control response detection step of detecting a first control response corresponding to the first limit cycle;

the manipulated variable change ratio calculation step of determining, on the basis of the first control response, change instruction information for instructing which one of the heat-side manipulated variable set point and the cool-side manipulated variable set point is to be changed after the first limit cycle and a manipulated variable change ratio indicating a degree of the change;

the second limit cycle generation step of generating a second limit cycle by changing one of the heat-side manipulated variable set point and the cool-side manipulated variable set point on the basis of the change instruction information and the manipulated variable change ratio;

the second control response detection step of detecting a second control response corresponding to the second limit cycle; and

the control parameter calculation step of calculating the control parameter for each of the heat

mode and the cool mode on the basis of the detected first and second control responses.

3. A method according to claim 1, wherein

the feedback control computation includes PID control computation based on the control parameter including a proportional band, an integral time, and a derivative time,

in the first control response detection step, a first amplitude of a controlled variable is detected as the first control response,

in the second control response detection step, a second amplitude of a controlled variable, a heat-side elapsed time from the instant at which output of a manipulated variable set point is switched to a heat side to the instant at which the controlled variable reaches a minimum value, and a cool-side elapsed time from the instant at which output of a manipulated variable set point is switched to a cool side to the instant at which the controlled variable reaches a maximum value are detected as the second control response, and

in the control parameter calculation step, a ratio between a heat-side process gain and a cool-side process gain is obtained on the basis of the first and second amplitudes, the proportional band is calculated for each of the heat mode and the cool mode from the

ratio, and the integral and derivative times common to the heat mode and the cool mode are calculated from an average of the heat-side elapsed time and the cool-side elapsed time.

4. A method according to claim 2, wherein

the feedback control computation includes PID control computation based on the control parameter including a proportional band, an integral time, and a derivative time,

in the first control response detection step, a first amplitude of a controlled variable, a heat-side maximum deviation set when the controlled variable reaches a maximum value, and a cool-side maximum deviation set when the controlled variable reaches a minimum value are detected as the first control response,

in the second control response detection step, a second amplitude of a controlled variable, a heat-side elapsed time from the instant at which output of a manipulated variable set point is switched to a heat side to the instant at which the controlled variable reaches a minimum value, and a cool-side elapsed time from the instant at which output of a manipulated variable set point is switched to a cool side to the instant at which the controlled variable reaches a maximum value are detected as the second control

response,

in the manipulated variable change ratio calculation step, the change instruction information and the manipulated variable change ratio are determined on the basis of the heat-side maximum deviation and the cool-side maximum deviation, and

in the control parameter calculation step, a ratio between a heat-side process gain and a cool-side process gain is obtained on the basis of the first and second amplitudes, the proportional band is calculated for each of the heat mode and the cool mode from the ratio, the integral and derivative times in the heat mode are calculated from the heat-side elapsed time, and the integral and derivative times in the cool mode are calculated from the cool-side elapsed time.

5. A heat/cool control apparatus which has a limit cycle autotuning function of calculating a control parameter by alternately performing operation of outputting a predetermined heat-side manipulated variable set point to a heating actuator and operation of outputting a predetermined cool-side manipulated variable set point to a cooling actuator, and performs temperature control in normal operation by properly switching a heat mode of outputting a manipulated variable to the heating actuator and a cool mode of outputting a manipulated variable to the cooling

actuator, comprising:

control computation means for calculating a manipulated variable to the heating actuator or the cooling actuator by performing feedback control computation with respect to a deviation between a set point and a controlled variable on the basis of the control parameter in the normal operation;

manipulated variable change ratio storage means for storing in advance change instruction information for instructing which one of the heat-side manipulated variable set point and the cool-side manipulated variable set point is to be changed during the autotuning, and a manipulated variable change ratio indicating a degree of the change;

limit cycle generating means for generating a second limit cycle, during execution of the autotuning, by changing one of the heat-side manipulated variable set point and the cool-side manipulated variable set point on the basis of the change instruction information and the manipulated variable change ratio after generating a first limit cycle of alternately outputting the heat-side manipulated variable set point and the cool-side manipulated variable set point;

control response detection means for detecting a first control response corresponding to the first limit cycle and a second control response corresponding to the second limit cycle; and

control parameter calculation means for calculating the control parameter for each of the heat mode and the cool mode on the basis of the detected first and second control responses, and setting the calculated control parameters in said control computation means.

6. An apparatus according to claim 5, comprising manipulated variable change ratio calculation means for determining the change instruction information and the manipulated variable change ratio on the basis of the first control response, in place of said manipulated variable change ratio storage means.

7. An apparatus according to claim 5, wherein

said control computation means performs PID control computation on the basis of the control parameter including a proportional band, an integral time, and a derivative time,

said control response detection means detects a first amplitude of a controlled variable as the first control response, and detects a second amplitude of a controlled variable, a heat-side elapsed time from the instant at which output of a manipulated variable set point is switched to a heat side to the instant at which the controlled variable reaches a minimum value, and a cool-side elapsed time from the instant at which output

of a manipulated variable set point is switched to a cool side to the instant at which the controlled variable reaches a maximum value as the second control response, and

said control parameter calculation means obtains a ratio between a heat-side process gain and a cool-side process gain on the basis of the first and second amplitudes, calculates the proportional band for each of the heat mode and the cool mode from the ratio, and calculates the integral and derivative times common to the heat mode and the cool mode from an average of the heat-side elapsed time and the cool-side elapsed time.

8. An apparatus according to claim 6, wherein

said control computation means performs PID control computation on the basis of the control parameter including a proportional band, an integral time, and a derivative time,

said control response detection means detects a first amplitude of a controlled variable, a heat-side maximum deviation set when a controlled variable reaches a maximum value, and a cool-side maximum deviation set when a controlled variable reaches a minimum value as the first control response, and detects a second amplitude of a controlled variable, a heat-side elapsed time from the instant at which output of a manipulated

variable set point is switched to a heat side to the instant at which the controlled variable reaches a minimum value, and a cool-side elapsed time from the instant at which output of a manipulated variable set point is switched to a cool side to the instant at which the controlled variable reaches a maximum value as the second control response,

said manipulated variable change ratio calculation means determines the change instruction information and the manipulated variable change ratio on the basis of the heat-side maximum deviation and the cool-side maximum deviation, and

said control parameter calculation means obtains a ratio between a heat-side process gain and a cool-side process gain on the basis of the first and second amplitudes, calculates the proportional band for each of the heat mode and the cool mode from the ratio, calculates the integral and derivative times in the heat mode from the heat-side elapsed time, and calculates the integral and derivative times in the cool mode from the cool-side elapsed time.